Trial through Communication Games for Teamwork Skill Enhancement at First-year Students in Science and Technology Course

Hiroyuki Matsumoto[1,a], Kenji Amagai[2,b] and Yasushi Yuminaka[2,c]
[1]*Support Center of Improving Program for Students' Employability, Gunma University, 4-2 Aramaki-machi, Maebashi, Gunma, 371-8510 Japan*
[2]*Support Center of Improving Program for Students' Employability, Kiryu Branch, School of Science and Technology, Gunma University, 1-5-1 Tenjin-cho, Kiryu, Gunma, 376-8515, Japan*
[a]*matsugen@gunma-u.ac.jp*, [b]*amagai@gunma-u.ac.jp*, [c]*yuminaka@gunma-u.ac.jp*

Abstract

The Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan had been promoted a "program of student employability" to cultivate a sense of sociality and independence in university education. Reflecting these trends, educational programs to improve the teamwork skills are in demand. At our university, first-year students are trained in group work skills and cooperative education. For this purpose, Career Planning and Career Design courses are offered during first and second semesters of first-year education. Enhancement of teamwork skills at an early stage of education is deemed extremely important. In this paper, we report on a training program to enhance teamwork skills for first-year students of science and technology. Communication games were used to evaluate the importance of communication and teamwork. The effect of this trial was analyzed through a student questionnaire. As a result, we confirmed that students experienced the importance of teamwork for the solving of problems through the trial of teamwork ability using communication games.

Keywords: Communication ability, teamwork ability, career education, communication game, JABEE.

Introduction

Communication skills are essential in industry and business. Existing research on teamwork in working groups was investigated. McEwan et al. (2017) discussed the effectiveness of teamwork from the systematic literature review. Lacerenza et al. (2018) investigated about the effectiveness of team development interventions (TDIs) for increasing the team competencies. Wu & Chen (2014) carried out the factor analysis on teamwork performance as an empirical study. Team building is also an important theme for research in the fields of business and industry. Saraswat & Khandelwal (2015) investigated the effect of team building exercises on team effectiveness to the service sector of company. Purohit (2015) reported the case study on the team building and performance improvement at Government Health Centers. Sulaiman et al. (2012) discussed the human resource management and administration that focuses on the effectiveness of team building. Consequently, enhancing students' communication skills is an important issue in higher education. Teamwork skills are vital in various work settings such as industry, medicine, welfare and business. Notably, teamwork is a necessary ingredient of innovation and development of new technology or systems. Universities must meet these needs for teamwork skills through education. Mohd-Yusof (2015) introduced the engineering program accreditation manual of the Malaysian Engineering Accreditation Council in which the competence of "Individual and Team Work" was included. Lingard (2010) and Lingard & Barkataki (2011) studied on the teaching and assessing the teamwork skills in engineering and computer science.

The concept of generic skill was first defined by the Karmel committee in Australia, 1985 (ANTA, 2003). This Committee was the "Quality of Education Review Committee" chaired by Peter Karmel. In their report at 1985, they recommended that students prepared the enough education for employment through the skills such as communication and working in groups in order to create an internationally competitive labor force of Australia. This work was inherited by the Mayer committee, which developed key competencies for improving graduates' employability. Teamwork and communication skills were introduced as key competencies in the early stages of generic skills. Communication skills are a basic competence to build human relations and to work smoothly in a team. Enhancement of students' communication skills was an important research topic. Studies on teamwork skills in university education were also carried out (Rodzalan & Saat, 2012; Rahman et al., 2011, Yong & Ashman, 2019; Le & Tam, 2008), whose effects were evaluated. Teamwork skills were researched through Project-Based Learning (PBL) (Borhan, 2012). Other studies dealt with Cooperative or Collaborative Learning. It is thought that these techniques, in which teams solve specific problems, produce extremely

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effective learning (Gokhale, 1995; Ghazali et al., 2019; Gillies, 2016; Estébanez, 2017). Students in engineering fields in the United States undertake a "Capstone Design Course" in the final stage of higher education (Viswanathan, 2017; Glakpe et al., 2010). In this course, students solved real problems in teams. This experience was effective in enhancing teamwork skills and to form a bridge between university education and industry.

Japan has put forth several educational reforms to enhance the teamwork skills. The Central Council for Education in MEXT published a strategy of 21st century of education reform (MEXT, 2001). In 2008, MEXT proposed "Bachelor degree student abilities" as a response to the recommendations made by the Central Council for Education. This was similar to the generic skill concept. Communication and teamwork skills were introduced as important competencies to be acquired at university (MEXT, 2012). In general, Japanese young people had been said that they are not good at active communication. In recent years, however, Japanese young people have come to insist themselves. We could not find the investigations and published research works about this fact. However, we feel about this change from our long span educational experience. It is thought that not only the educators but also many people in Japan are sharing the similar impression.

The Japan Accreditation Board for Engineering Education (JABEE) is an assurance body to evaluate and accredit the educational programs of the higher education institutions such as universities and was established as a non-governmental organization (NGO) in 1999. JABEE is also a member of the Washington Accord. JABEE has an assurance system for engineering education and has been adopted in many Japanese universities (146 universities and colleges as of April 2020). The target of JABEE was the improvement and standardization of university engineering education. One important criteria of JABEE verifies whether the students are taught international attributes such as design ability, communication skills, and the ability to work in a team (JABEE, 2019). The specific common criteria for communication skills and teamwork skills are listed as:

- Communication skills including logical writing, presentation and debating
- The ability to work in a team

The Accreditation Board for Engineering and Technology (ABET) is an authentication system of higher education in United States. It has published general criteria of student outcomes for communication and teamwork skills, as follows (ABET, 2019):

- An ability to communicate effectively with a range of audiences
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

The Japanese Ministry of Economy, Trade and Industry (METI) proposed "Essential Competencies" in 2006 (METI, 2018). It defined key competencies as a necessary ability for young people to work, among the most important, teamwork. Industry has requested this ability to be taught in higher education. According to METI's "Essential Competencies", six elements were listed as key competencies of teamwork skill i.e. (i) an ability to convey opinions, (ii) an ability to listen carefully to others' opinions, (iii) an ability to understand differing opinions, (iv) an ability to understand the relationship between team members, (v) an ability to follow team rules, and (vi) an ability to endure stress.

Although industry made demands for education programs of teamwork skill training, few classes in university curricula existed. For their graduation research, students are normally assigned a single research topic, which they carry out as individuals. In light of this, it seems appropriate that students of engineering and technology majors engage in teamwork at an early stage of their learning in university. It was thought that the enhancement of teamwork skills is deemed extremely important as described above. Especially, experience of teamwork activities is important at an early stage of education. At our university, first-year students are trained in group work skills and cooperative education. For this purpose, Career Planning and Career Design courses are offered during first and second semesters of first-year. In this paper, the authors share the results of a trial training program for developing teamwork skills. As part of the instruction, communication games were employed to understand communication and teamwork skills.

Questionnaire on Communication and Teamwork Skills

Questions on Communication

(1) Methodology of the questionnaire survey

A questionnaire survey on communication and teamwork skills was conducted with 163 first-year students enrolled in a "Career Design" course, in the program of science and technology in 2019. The "Career Design" course, an elective subject, was offered in the second semester of the first year under the auspices of "student employability" (Anonymous, 2012, Anonymous, 2020). Students of five departments were enrolled and answered the questionnaire, as in Table 1.

In order to conduct a questionnaire survey, the contents of the questionnaire were shown to all the students in the class via a projector. The answer data was obtained by online survey tool through the student's mobile device. As the online survey tool, Google Forms was used. Since the survey results were

immediately disclosed to students in the class, it was a very effective tool for students to know and discuss the results.

Table 1. Number of respondents and their departments

Department	N
Chemistry and Chemical Biology	77
Mechanical Science and Technology	32
Environmental Engineering Science	24
Electronics and Informatics, Mathematics and Physics	22
Integrated Science and Technology	8
Total	**163**

Two questionnaire items were created to understand the students' awareness of communication skills. The first question was "Do you like talking to other friends?". Students could select from five answers on a Likert scale: "Yes", "If anything, I choose Yes", "Neither Yes nor No", "If anything, I choose No" and "No".

(2) Results and findings

Figure 1 shows the results. The majority of the students, 58.9%, answered "Yes" and "If anything, I choose Yes". This value was much higher than the answers of "If anything, I choose No" and "No". Many students declared that they like talking with their friends.
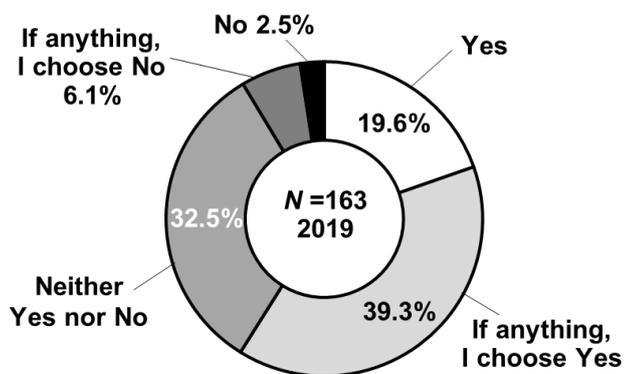

Figure 1. Results of first question: "Do you like talking to friends?"

The second question was: "Do you think that you are good at communicating with other people?". Students could select from the following answers of the same scale. Results are shown in Figure 2. Answers of "Yes" and "If anything, I choose Yes" are only 27%. Conversely, 39.3% students selected the "No" and "If anything, I choose No". This result suggests that students think they are not good at communication. From a comparison of Figure 1 and Figure 2, it is presumed that many students like conversation with their friends but feel that they are not good at communicating.
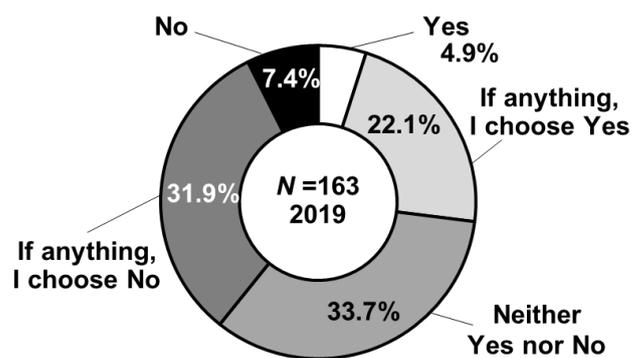

Figure 2. Results of second question: "Do you think that you are good at communicating with other people?"

Questions on Teamwork Experience

(1) Methodology of the questionnaire survey

Questionnaire surveys were conducted to examine past experiences of student team activities. Three more questions were devised in order to investigate students' experience with teamwork. Respondent's data were same as Table 1. Same online survey tool was used to obtain the answer.

(2) Results and findings

The first question was "Have you ever done work in a team in order to solve a problem?". Students could choose one of three answers: "Yes", "No" and "I don't remember". The results in Figure 3 show that most students have had experience of teamwork. To follow up this question, we asked what kind of activities were done as a team. Students responded that they had worked in a team through club activities and research projects in high school. However, nearly 40% answered "No" or "I don't remember".
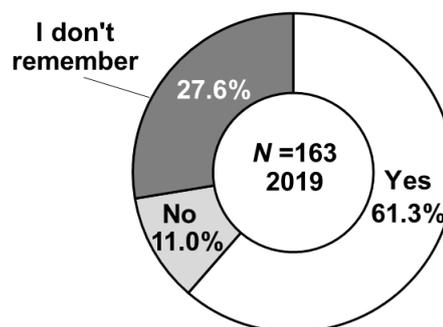

Figure 3. Results of question: "Have you ever done work in a team in order to solve a problem?"

The second question regarding teamwork was "Do you like solving a problem in a team?", again using the 5-point Likert scale. The results, Figure 4, suggest that many students enjoy problem-solving in a group or team. Figure 3 and Figure 4 would seem to indicate students had experience of teamwork, and that they rather enjoy working with others. However, more than 10% felt that teamwork was disagreeable.

Furthermore, more than 40% selected the "Neither Yes nor No". Total percentage of negative answers was more than the sum of positive answers. Comparing the results from Figure 2 and Figure 4, it appears that students tend to prefer teamwork activities to individual communication.
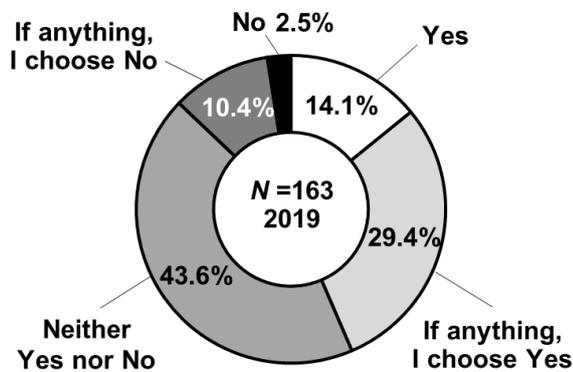

Figure 4.　Result of question: "Do you like solving a problem in a team?"

The final question about teamwork was: "Do you think that teamwork is important to solve problems?" Respondents could choose one of three answers: "Yes, I think so", "Neither Yes nor No" and "No, I don't think so". Figure 5 shows that many students recognize that teamwork is important to solve problems.
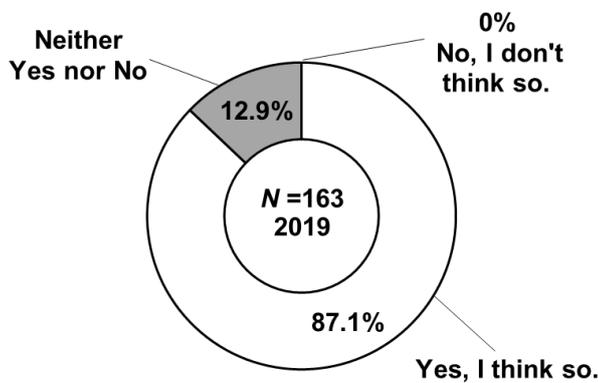

Figure 5.　Results of question: "Do you think that the teamwork is important to solve problems?"

Trials to Confirm the Importance of Teamwork using Communication Games

Methodology of the Communication Game

Communication games are widely used as a way to easily experience that the two-way information was more informative rather than one-way communication. However, there were very few investigations that have been studied theoretically. In this communication game, participants must listen to a speaker's description of a diagram and draw an illustration as accurately as possible (Tsuji et al., 2015). Rules of the game are as follows;

(1) Students form a group of 7-8 members.
(2) Students choose a speaker for each group. The other students are listeners.
(3) The speaker describes the diagram orally.
(4) Listeners draw the diagrams as accurately as possible, according to the speaker's description.

Then, three types of communication were tested, as shown in Figure 6.
(a) Game A: The speaker verbally explains the diagram; no questions are allowed (one-way message).
(b) Game B: The speaker verbally explains the diagram; Listeners can ask questions individually to the speaker and the speaker can respond (interactive communication), but listeners are not allowed to talk amongst themselves.
(c) Game C: The speaker verbally explains the diagram; Listeners can ask questions or clarification from the speaker while discussing within the group and the speakers can respond actively (team communication). The group will reach a common answer by consensus.

The speaker's time was limited to 5 minutes in each game. Figures used in each communication games are shown in Figure 7. Simple geometric shape was used in order to explain easily for the listener.
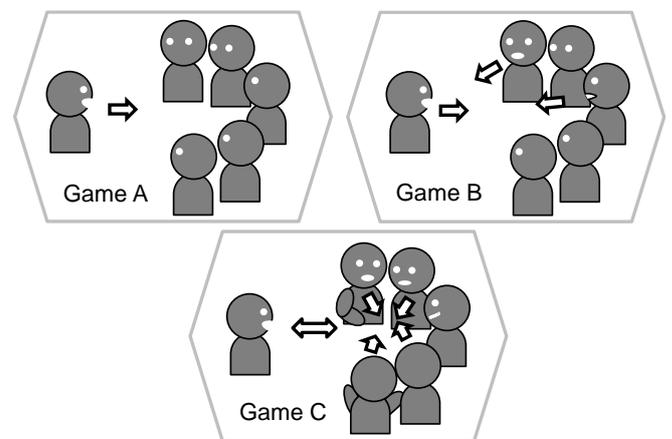

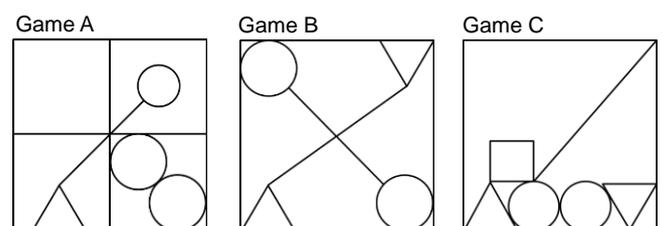**Figure 6.　Three types of communication styles tested via communication games**

Figure 7.　Diagrams used in the communication games

For this activity, 941 students took part, as shown in Table 2. Students in three different courses participated. The first was "Career Planning", which was offered in the first semester of the freshman year as a required subject in 2016. In 2018 and 2019,

students of "Career Design", an elective subject class also joined in, as summarized in Table 1.

Table 2. Communication Game Participants

Year	N	Class
2016	526	Career Planning (required, first semester)
2018	253	Career Design (elective, second semester)
2019	162	Career Design (elective, second semester)

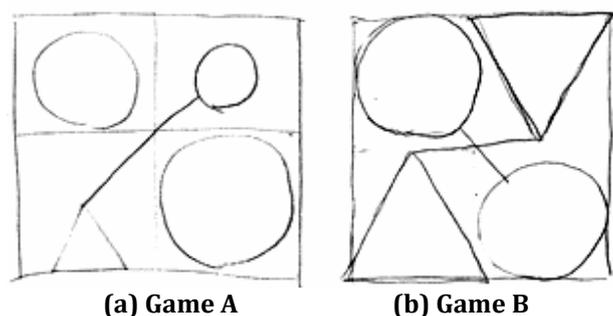**Figure 8. Students playing the Communication Game**

| (a) Game A | (b) Game B |

Figure 9. Sample of incorrect figures for Games A and B
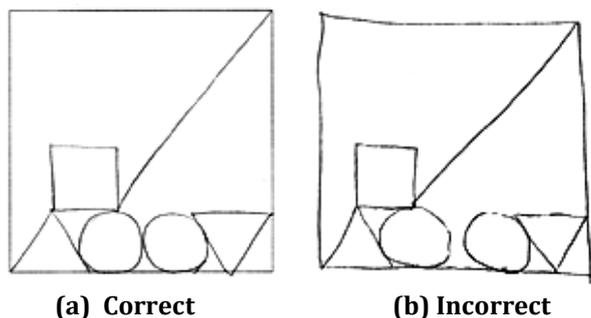

| (a) Correct | (b) Incorrect |

Figure 10. Sample of correct and incorrect figures for Games C

Results of Communication Games

In the photograph (Figure 8) the speakers have a card with the target illustration. Figure 9 shows samples of incorrect figures for Game A and B drawn by the listeners. Figures of the correct answer were shown in Figure 7. How the students correctly drawn the figure compared to Figure 7 was checked. In Game

A, the circle and triangle were nearly correct but the arrangement of the circles was incorrect. In Game B, shapes of the circle and triangle were correct but the scale was incorrect. If the participants were unrestricted and allowed to discuss and ask questions of the speaker, the participant might have adjusted the size.

In Figure 10 (a), many listeners drew it correctly. However, some incorrect answers were observed, as shown in Figure 10 (b). In this case, the two circles were separated. It was thought that accurate communication was not carried out because there was an insufficient information exchange caused by the one-way transmission of information at the communication games.

The percentages of correct answers for each game are summarized in Figure 11. Similar trends were observed each year. The percentage increases from Game A to B, and in case of C, more than 65% students answered correctly. From the comparison data of Games B and C, this result suggests that communication within the group enables more participants to accurately draw the figures.
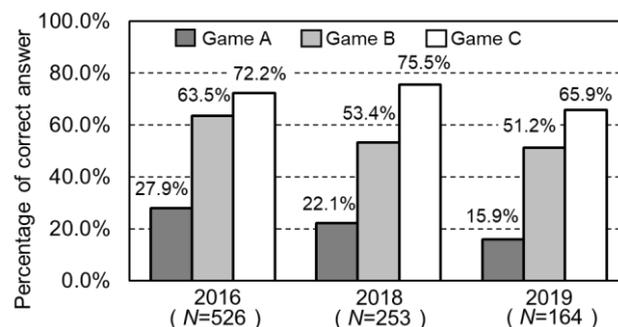

Figure 11. Percentages of correct drawings for Games A, B and C

Results and findings of Post-Activity Questionnaire on Teamwork Skills through Communication Games

Students should have raised their awareness about communication skills through playing these games. In Game A, the speaker likely felt that difficulty in explaining because the speaker cannot know whether the listener understood correctly. Perhaps they realized that two-way communication is crucial for an accurate transmission of information.

A post-activity questionnaire was conducted to the same participants shown in Table 2 but two students did not answer at 2019. First question was "Through Games A and B, was it easier to understand by asking and answering questions than only listening by one-way explanations?" As shown in Figure 12, more than 90% of students answered "Yes".

The second question was "Through Games B and C, was it easier to draw the figure while discussing it in a group than to ask a question individually?" As shown in Figure 13, more than 85% answered affirmatively.
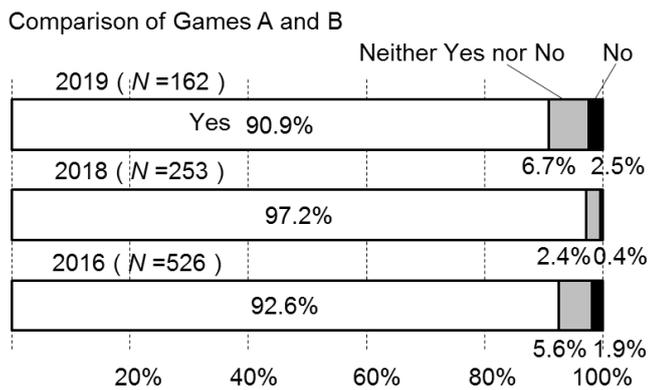
Comparison of Games A and B

Figure 12. Results of question "Through Games A and B, was it easier to understand by asking and answering questions than only listening to a one-way explanation?"

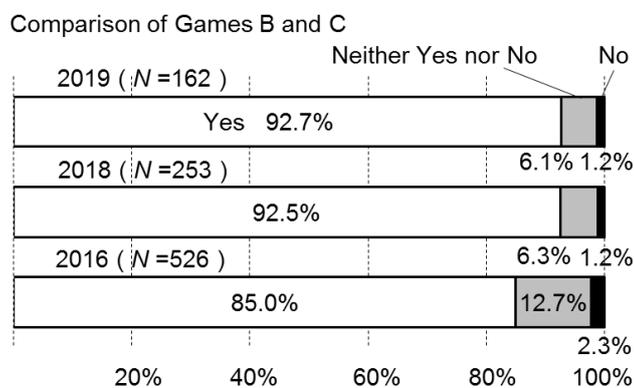Comparison of Games B and C

Figure 13. Result of question "Through the Games B and C, did you think that it was better to understand by writing a figure while discussing in a group than to ask a question individually?"

In this way, students felt that transmission of information became increasingly effective in the order of one-way transmit, two-way communication, and two-way communication with group discussion or teamwork. This pattern is the same as the percentage of correct answers in Figure 11.

Discussion

We reported the results of first-year students' awareness for the importance of communication and teamwork skills through the questionnaire survey at the first part of this article. It was confirmed that many students recognized the importance of communication and teamwork to solve the problems. Furthermore, from the trial of communication game activity, students could experience that the mutual communication and team discussion were important and effective for collaborating works. They would also understand that mutual communication increased the accurate transmission of the information through the communication game. These hypotheses were inspected by the results of the actual feelings of students obtained by questionnaire as shown in Figure 12 and Figure 13. Most of the students who entered the

university have no acquaintance after admission. Furthermore, as shown in Figure 2, many students feel that they are not good at communication. Therefore, the communication and teamwork activities introduced in our class were considered to be extremely important for first-year students. Improvement of the communication and teamwork skills will be required more and more before the start of professional educations.

Conclusion

An activity to enhance the teamwork skills via a communication game was carried out with first-year students majoring in science and technology. The effect of the activity was evaluated through a questionnaire survey. Questionnaire results showed that many students had previous experience in teamwork and they considered teamwork to be important in problem-solving. As a result of the trial of teamwork ability using communication games, students confirmed that teamwork is important for the solving of problems, as shown by the results of the questionnaire.

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